CHAPTER 5

FLOOD CONTROL AND WATER SUPPLY

Early accounts of Lake Okeechobee describe a lake that "usually stayed brim full, spilling over to the watery sawgrass plain which spread southward 100 miles or more" (Will 1977). In 1850, the Everglades was given to the state of Florida, with the provision that the state "reclaim" the lands, which had a profound effect on Lake Okeechobee. The first efforts were designed to protect agriculture in the northernmost portion of the Everglades by lowering the water level in the lake using canals that drained to the coasts, and the construction of a dike on the southern side to stop the normal flow from the lake. Since these earlier modifications, several efforts provided navigation, flood control and water supply, and the most current modifications are considered part of the C&SF Project, operated by the USACE. The major events (USACE, 1995) listed in Table 14 illustrate the development of the current system, which consists of approximately 140 miles of levees, control structures and canals system, collectively known as the Hoover Dike.

The once-natural lake and wetland system now functions as a multipurpose regional reservoir, storing vast quantities of water during the wet season for use during the dry season. Uses of the lake include: (1) flood control; (2) agricultural water supply; (3) urban and industrial water supply; (4) protection of wetland and estuarine systems, and enhancement of fish and wildlife resources; (5) prevention of saltwater intrusion; (6) navigation; (7) recreation; and, (8) water supply for Everglades National Park. Other entities, such as the Seminole Tribe of Florida and Miccosukee Tribe of Indians of Florida, also rely upon water from Lake Okeechobee.

The environmental concerns are an integral part of flood control issues. For example, when water levels rise too high, a tradeoff is forced between flooding of the marsh zone (Milleson, 1987), and releases of excess freshwater harmful to the estuaries (Haunert and Startzman, 1985). In contrast to high water levels, when the lake stage is too low for prolonged periods of time, there is the danger of drying out the marsh zone or allowing the estuaries to become hypersaline, which allows invasion of exotic vegetation. Major projects currently underway, such as Everglades Restoration (SFWMD, 1995b), are also expected to have a significant impact on the quantity of water in Lake Okeechobee.

The Environmental Resources Chapter captures the major challenges and strategies derived from the materials contained within this chapter.

Table 14. Chronology of Events for Hover Dike (USACE, 1995)

1850 - The Swamp and Overflowed Land Grant Act of 1850 vested title of the Everglades to the State of Florida, on conditions that proceeds of sales be applied to reclamation of lands. The area received immediate consideration by agricultural interests due to its fertile lands and mild winters.

1855 - The State Legislature created the Trustees of the Internal Improvement Fund to administer the overflowed lands.

1881 - The first contract for construction of drainage canals was let in 1881, but little actual progress was made until 1902.

1905 - The Legislature created the Everglades Drainage District to further reclamation work. This led to more extensive operations which began in 1906 and continued to 1929, when work practically ceased due primarily to depletion of funds.

1912 - Everglades Drainage District began recording lake stages and rainfall amounts.

1926 - Hurricane struck on 18 September 1926. 386 lives were lost at Moore Haven. Property damages were estimated at $6,000,000.

1928 - Hurricanes struck on 16 September and 28 November 1928. Approximately 2700 lives were lost. Property damages were estimated at $75,000,000.

1930 - The River and Harbor Act of 1930 included a navigation and flood control project for the Caloosahatchee River and Lake Okeechobee drainage areas. Features included construction of:

a. Caloosahatchee Canal and River improvements.
b. Taylor Creek improvements.
c. Levee and navigation channel along south shore.
d. Levee along north shore.
e. St. Lucie River improvements.
f. Protective works in St. Lucie Canal.

1932 - Actual levee construction began on 6 January 1932. The south shore levee system from Fisheating Creek to St. Lucie Canal was completed on 21 March 1936.

1933 - Hurricane struck 3 September 1933. Uncompleted levee at Bacom Point was severely eroded but not breached. No loss of lives was reported.

1935 - The River and Harbor Act of 30 August 1935 provided that U.S. maintain and operate all project works when completed.

1936 - North shore levee construction began 22 July 1936 and was completed 3 February 1938.

1947 - Two hurricanes and related flood conditions caused flood damages estimated at $60,000,000; however, there was no loss of life.

1962 - Construction of L-48, L-49, and L-50 levees on the northwest shore was completed.

1965 - L-47 levee construction on the northeast shore began in August 1965 and was completed in November 1967.

1965 - Construction associated with levees L-D1, L-D2, L-D3, L-D4, L-D9, and L-52 was completed.

1966 - Completed construction of spillway (S-77) at Hurricane Gate Structure (HGS) HGS-1.

1973 - Completed HGS to lock conversion at HGS-6 (S-193).

1980 - Completed HGS to lock conversion at HGS-2 (S-310).

1986 - Revetment Contracts 2 (N. WPB Canal and Liberty Point) and 4 (Bacom Point) completed.

1987 - Revetment Contract 6 (west of Clewiston) was completed.

1988 - Revetment Contract 1 (south of Port Mayaca and at Pahokee State Park) was completed.

1989 - Revetment Contract 3 (Port Mayaca and Nubbin Slough) was completed; also completed HGS to spillway conversions at HGS-4 (S-351) and HGS-5 (S-352).

1990 - Completed HGS to spillway conversion at HGS-3 (S-354).

A. GOALS, OBJECTIVES AND STRATEGIES

Goal 1: Ensure adequate flood protection to local communities and agriculture around the lake.

Objective 1: Upgrade the efficiency and stability of flood control facilities within the Lake Okeechobee Basin and provide for the maintenance and control of aquatic weeds to ensure project design capacity is met for inflow and discharge canals and structures.

Strategy 1: Support the USACE's completion of the Hoover Dike Major Rehabilitation report.

Strategy 2: Maintain design flow and conveyance capacities of the flood control system by continuing the aquatic weed maintenance at inflow/discharge structures and canals, consistent with other lake management objectives.

Strategy 3: Assist local governments in their comprehensive planning process to address local flood protection needs, consistent with water quality and environmental resource objectives.

Objective 2: Reduce the Everglades Agricultural Area=s dependency on the lake and Water Conservation Areas for flood control as much as practical.

Strategy 1: Maintain present reductions in the use of S-2 and S-3 pumps for flood protection in the S-2 and S-3 basins.

Strategy 2: Assist the USACE in developing a comprehensive plan for the Bolles and Cross canals to reduce agricultural flood damages in the EAA and enhance the capacity for the interbasin transfer of water.

Goal 2. Provide a balance between the competing objectives of flood protection, water supply and protection of the lake's marsh zone and downstream estuaries.

Objective 1: Work actively with the USACE and state agencies in re-evaluating the Lake Okeechobee regulation schedule as the local sponsor.

Strategy 1: Coordinate meetings/facilities and participate in presentations of the Lake Okeechobee Regulation Schedule Study (LORSS).

Strategy 2: Provide updated vegetation maps from the Lake Okeechobee marsh zone.

Strategy 3: Provide the modeling output to the USACE environmental and economic analyses.

Objective 2: Work as the local sponsor with the USACE in C&SF Feasibility Study.

Strategy 1: Cooperate with the USACE on developing new biological data for the major vegetation communities in the marsh zone of Lake Okeechobee.

Strategy 2: Collect additional data from the marsh zone of Lake Okeechobee that evaluates the effect of lake stage on the vegetation communities.

Goal 3: Maintain an adequate quantity of water in Lake Okeechobee to supplement downstream environmental needs and reasonable-beneficial use requirements.

Objective 1: Provide water deliveries for use by agriculture and urban communities around the lake and aquifer recharge in the coastal region.

Strategy 1: Define urban and agricultural water supply needs that utilize Lake Okeechobee.

Strategy 2: Continue to implement the current Supply Side Management Plan for allocation of water deliveries to the EAA during a declared water shortage as described in the SFWMD Water Shortage Manual.

Objective 2: Provide water supply for supplementing environmental needs through the Lower East Coast Regional Water Supply Plan.

Strategy 1: Establish environmental water needs for Lake Okeechobee, the St. Lucie and Caloosahatchee estuaries, the Water Conservation Areas, and Everglades National Park for the protection of natural vegetation, fish and wildlife habitat, and protection of rare, threatened or endangered species.

Strategy 2: Define the role of Lake Okeechobee in meeting the water needs of the downstream environment.

Strategy 3: Develop a flexible framework for managing the operation of the lake at stages below regulation, including the modification of the Supply Side Management Plan.

Objective 3: Reduce dependency on Lake Okeechobee as a water supply for downstream users through implementation of demand management and water conservation techniques and development of alternative sources of water supply.

Strategy 1: Require that permitted users within the Lake Okeechobee service area develop and implement water demand management strategies.

Objective 4: Augment water supply from Lake Okeechobee consistent with environmental objectives.

Strategy 1: Investigate methods for development of additional sources of water to the lake which would not adversely effect its trophic state, marsh zone or downstream estuaries.

Strategy 2: Investigate and research alternative (non-lake) options for supplying agricultural and public water supply demands (e.g., wastewater reuse, industrial and agricultural recycling, alternate surface water storage facilities, aquifer storage and recovery, and desalination technologies).

Strategy 3: Investigate and promote the use of optimization technology on the operation and location of coastal wellfields in order to reduce the potential of saltwater intrusion and therefore demands on Lake Okeechobee.

Strategy 4: As water use permits within the Lake Okeechobee service area come up for renewal, examine and, if necessary, revise them to insure consistency with the Lake Okeechobee water budget, applicable SWIM and water supply plans, modified regulation schedule and any other identified natural resource management needs of the lake.

B. FLOOD CONTROL

Flood control provides the protection for the area around the lake from flooding, and is a function of water storage capacity based on the structural limitations of the Hoover Dike. There are two ways flood control is achieved to protect life and property adjacent to Lake Okeechobee. First, levees completely encircle the lake except where it connects to high ground on either side of Fisheating Creek. Second, lake stage (water level) is monitored daily by the USACE and the SFWMD, and this information is evaluated according to the lake regulation schedule (described in section 3 of this chapter). The general concept is to insure that sufficient storage capacity is available for basin runoff and rainfall. The regulation schedule is at its lowest point before the start of the rainy season on June 1 of each year. The regulation schedule must maintain levels in the lake that are safe even with the occurrence of hurricane wind tides and wave action. Although intense rainfalls amounting to 4 inches or more are common in Florida, serious flooding usually is the result of prolonged heavy seasonal rainfall aggravated by tropical storm or hurricane rains.

B1. Flood Control Canals and the Hoover Dike

B1a. Canals

One of the first main constructed outlets for the lake was a channel begun in 1884, connecting Lake Okeechobee with the headwaters of the Caloosahatchee River, to improve access to the lake. The original channel was improved a number of times between 1906 and 1935, and the last improvement was made by the federal government in 1949. The channelized portion of the Caloosahatchee River (C-43) now consists of an 8-foot deep channel, 90 feet wide, from Lake

Okeechobee to the Franklin Lock and Dam (S-79), and is one of two main flood control canals. The second main flood control canal is the St. Lucie Canal, initially built because local residents needed to reduce flood hazard to low-lying lands. Construction began in 1916 and was completed by 1924. The canal was excavated through sandy soils throughout its length, resulting in nearly vertical banks. The USACE subsequently deepened the canal using similar dredging techniques. Regulatory discharges from Lake Okeechobee in combination with boat wakes have been frequent enough to prevent natural bank stabilization. Some areas have already eroded beyond the right-of-way line and other areas are endangered.

Agricultural canals were dug as early as 1900, when settlers started developing the rich muck lands immediately south of Lake Okeechobee. Because of the wet character of those lands, drainage was the primary requirement for successful development. Construction of four major canals to drain the area started when the Everglades Drainage District began large-scale work in 1906 and progressed as funds became available until about 1929. During the period from 1906 to 1910, 11.2 miles of the North New River Canal and 4.2 miles of Miami Canal were excavated. By April 1913, the Miami and North New River Canals were connected to the ocean, and work on the West Palm Beach Canal had been started. During this same time period, the Hillsboro Canal was being constructed, and although it had not been excavated to the ocean, it was discharging water from the lake to the Everglades.

These four canals were only partially successful in providing adequate drainage to the area, although they did permit partial development of the area. Although the Lake Okeechobee regulation schedule prioritizes the use of these canals for discharge when capacity is available, these four canals support only limited releases of water from the lake. During regulatory releases, the entire region is usually experiencing excess rainfall and runoff, and the use of these canals is constrained by their conveyance capacity and primary purpose of local flood control.

B1b. Hoover Dike

The Hoover Dike began as a project of the state of Florida with the construction of 47 miles of low levees in 1927. After the levee failed during the 1928 hurricane, levee reconstruction and expansion was authorized under the River and Harbor Act of July 3, 1930. This was later modified by the River and Harbor Act of August 3, 1935, to provide for maintenance of all project works completed. Construction of the levees under the River and Harbor Act of 1930 was started in 1931 along the south shore of the lake and by 1937, 69.2 miles of continuous levee along the west, south, and east shore of Lake Okeechobee were completed.

In 1948, the Comprehensive Plan for flood control and other project purposes was presented in the report to the Chief of Engineers on Central and Southern Florida, published as House Document 643 (80th Congress, 2d Session), and is also known as the Central and Southern Florida (C&SF) Project. The project was partially authorized by the Flood Control Act of 1948 (Public Law 858, 80th Congress, 2d Session). That authorization included most of the works necessary to afford flood protection to the rich agricultural development south of Lake Okeechobee and to the highly developed area along the lower east coast. The purposes of the overall C&SF Project include: flood control; navigation; water supply for agricultural irrigation, municipalities, industry, and Everglades

National Park; regional ground water control, and salinity control; enhancement of fish and wildlife; and recreation.

In January 1961, the levee system around the lake was dedicated and renamed the Hoover Dike in honor of the former president and the part he played in implementing the construction of these levees. The Hoover Dike was raised and improved from 1962 to 1967 as part of the 1948 plan. The Flood Control Act of 1968 (Public Law 483, 90th Congress, 2d Session) provided for further raising of the Lake Okeechobee regulation schedule and, accordingly, the Hoover Dike. In 1975, a report was approved that recommended improvements to 60.3 miles of the dike needed to raise the lake regulation schedule. In July 1990, the South Atlantic Division of the USACE stated that the costs were too high for slope protection and continued efforts in this were terminated. When work on the Hoover Dike was terminated, only 24.3 miles of the levee that had been scheduled for slope protection were completed.

In 1993, a special report was prepared by the USACE entitled Hoover Dike, Seepage and Stability Analysis. The report was undertaken to study the potential for problems related to seepage and structure stability of the levee system surrounding Lake Okeechobee. This report has led to current efforts by the USACE to conduct detailed field work on the condition of the dike, and the results will be prepared for the report, "Hoover Dike Major Rehabilitation", scheduled to be completed in June, 1998. Additionally, a structural report was prepared by the USACE in 1992 entitled Hoover Dike Culverts. The report identified culverts in the Hoover Dike which directly border on Lake Okeechobee which are in critical need of repair and/or replacement. The suggested repairs in this report will be completed in March 1997. This report also addressed future anticipated repairs, replacement, or abandonment of Lake Okeechobee culverts.

B1c. Bolles and Cross Canals Improvements

The need for the improvement of the Bolles and Cross canals was identified in the 1989 Lake Okeechobee Interim SWIM Plan and the 1993 Lake Okeechobee SWIM Plan Update. Improvements to the Bolles and Cross canals will allow better movement of water during local storm events and should result in a decrease in intermittent backpumping to the lake. At present, the Cross Canal lacks a protective berm, and both canals lack adequate cross sectional size to properly convey water from adjacent farm lands during major storm events. However, interim work has been conducted by the SFWMD on eight miles of levee along the south side of the Bolles Canal. The levee elevation was increased to 17 ft. NGVD to avoid future flood damages to adjacent agricultural lands.

As part of the C&SF Project, the USACE is preparing a General Re-evaluation Report (GRR) and an Environmental Impact Statement on improvements to the Bolles Canal, to be completed in 1998. In October, 1995, the USACE began surveying, taking core borings to determine the nature of sediments/bedrock, and modeling the interbasin flow at the request of the SFWMD. The USACE will assess both the economic and water quality aspects of the "with and without" project to determine the extent of federal involvement. The surveying and core borings currently being conducted are essential for the canal improvement plans and specifications regardless of who performs the improvements. Presently, the GRR is being developed to be of sufficient detail to go directly to plans and specifications.

B1d. The Interim Action Plan

The Interim Action Plan (IAP) was implemented by the SFWMD in 1979 to divert EAA runoff away from Lake Okeechobee and toward the Water Conservation Areas while maintaining adequate levels of flood protection in the EAA. The IAP allows pumping for emergency flood control and water supply situations in the S-2 and S-3 basins. These events result in backpumping nutrient-rich EAA waters north into Lake Okeechobee (see Water Quality Chapter). A threshold elevation of 13 ft. NGVD at the S-2 and S-3 pump stations is an operational constraint imposed by the USACE under the original C&SF Project. This operational constraint was based on the land surface elevations measured during the mid 1950s. The level of flood protection afforded by the 13 ft. NGVD control elevation has declined over the life of the project due to the subsidence of muck soils within the EAA. Future consideration of flood control efforts in this area should be addressed by finding alternative ways of removing flood waters through existing or modified canals and structures, rather than increasing backpumping to Lake Okeechobee.

B2. Regulation Schedule

Prior to the 20th century, Lake Okeechobee received large inflows from regions to the north which were drained by the Kissimmee River, Fisheating Creek, Taylor Creek, and Nubbin Slough. The only significant outflows occurred through the Everglades and through the marsh separating the lake from the Caloosahatchee River. On the south side of the lake the boundary between the lake and the Everglades was often indistinguishable during wet periods. Water movement was very slow to the south due to the flat terrain and thick vegetation. Before the period in which Lake Okeechobee was regulated, the average water level in the lake was near 19 ft. NGVD. It was not uncommon for water levels in the lake to rise above 20 ft. NGVD.

The lake regulation schedule was developed to provide a balance between storage capacity during the wet season, and water stored for use during the dry season. In 1940, a plan of operation was put in effect that was based on a rainfall and evaporation formula developed by the USACE from a study of the lake hydrological records. Several other schedules have been implemented over the past 56 years, often in response to weather. For example, drought often led to recommendations for a higher schedule, with the net result of more water stored. Refinements to the current regulation schedule are anticipated to enhance the health of the marsh zone of the lake.

B2a. Regulatory Releases

The Lake Okeechobee regulation schedule determines the timing and quantity of water that needs to be released from the lake when the stage exceeds a certain level, which varies according to season (see Figure 25). For example, May 31 is the lowest point of the regulation schedule (15.60 ft. NGVD), which corresponds to the beginning of the hurricane season. If the lake stage exceeded 17 ft. NGVD on this day, the lake would be in Zone A, and maximum discharges would be called for until the lake stage fell below 17 ft. NGVD. On the other hand, if the lake stage on this day is below 15.60 ft. NGVD, no releases would be required, although water withdrawals for water supply would be allowed. Another key date is the maximum lake stage allowable before releases are made. The current lake regulation schedule (Run 25, see details below) allows the lake to peak at

16.75 ft. on September 30th, and the water stored is intended for water supply during the dry season. The lake regulation schedule is often called a 15.60 to 16.65 ft. regulation schedule because of these key low and high lake stages.

The smallest release is called a Level I pulse release in Zone D, which discharges water into the St. Lucie and Caloosahatchee estuaries, and maximum discharges to the agricultural canals (West Palm Beach Canal, Hillsboro Canal, North New River Canal, and Miami Canal). See Section 1a in this chapter for constraints on these). This release follows a proscribed 10-day pattern of flow that mimics the natural hydrograph from the watershed (Guide for the Management of High Stages in Lake Okeechobee, 1992). A Level I release is designed to remove approximately 0.1 ft. of water from Lake Okeechobee in 10 days, or 0.3 ft. in a 30-day period.

To meet the targeted discharge volume, flow measurements are taken at S-80 in the St. Lucie canal. This structure captures significant runoff from the watershed as part of the flow measured at this location. If the target flow is met by watershed runoff, no discharges from Lake Okeechobee are made. In contrast, the targeted flow in the Caloosahatchee is measured at the point of discharge from the lake, (S-77); therefore, the watershed contribution is not included, although local drainage is considered before large releases are made from the lake. As a result of the flow-measuring locations, as well as input from direct precipitation and runoff from the watershed, the volume of water removed from the lake by pulse release (or any other regulatory discharge), may not be as great as expected.

Two additional levels of pulse releases, with a similar hydropattern as a Level I release but increasing flow, are part of Zone D. Once lake stage exceeds the Zone D, water is continuously discharged in the succeeding zones, C, B, and A. Each of these zones has a designated target flow, except Zone A, which allow flows up to a maximum, which is set by the capacity of the water control structures.

In Zone A, it is critical that the lake level be reduced as rapidly as possible to make room for the next possible flood event, to relieve stress and erosion of the levees, and to reduce impact on the lake's marsh zone. The release may be up to 9,300 cfs through the Caloosahatchee River (C-43). Lake regulatory releases are made after the peak of the local inflow has passed. The maximum capacity of the St. Lucie Canal (C-44 and C-44A) is 14,800 cfs and flows at the Lake Structure (S-308C) are regulated so that the flow at S-80 will not exceed 17,000 cfs.

Releases in Zone B are similar to Zone A, with a reduced flow to 6,500 cfs through the Caloosahatchee River, and 3,500 cfs through the St. Lucie Canal, measured at S-80. In Zone C, up to 4,500 cfs through the Caloosahatchee River and 2,500 cfs through the St. Lucie Canal are allowed. As described above Zone D, (pulse releases) and these continuous releases include maximum practicable flows to the Water Conservation Areas through the Agricultural Canals.

Below Zone D is Zone E, with releases made by SFWMD to the various users. Under the current LORSS there is no lower limit for Zone E; however, supply side management takes affect when the lake falls below certain stages, as described in section C4 later in this chapter. Although no flood regulation releases are required in Zone E, occasional advance flood releases can be made

during the late winter months with no loss of water supply benefits when operating within one-half foot below the top of Zone E, (e.g., June, 1996). This is done when unusually wet conditions prevail, and weather forecasts predict more of the same.

Continuous discharges to the St. Lucie and Caloosahatchee Estuaries have documented negative effects on the estuarine ecology (Chamberlain *et al.* 1995, Haunert and Startzman 1985, Chamberlain and Hayward 1996). Research has shown that prolonged releases, even at the modest Zone C rates, transform the estuarine systems into freshwater habitats within three to four weeks. The dramatic and rapid changes in salinities, and associated siltation which occurs, can produce long-term negative effects on these estuaries. In addition, continuous flow releases at these levels tend to create critically low benthic oxygen situations at the transitional zone between fresh water and the Ocean or Gulf. Zone A releases generate even more problems because of greater potential for environmental disruption and associated public concern. Even with a thorough understanding of these major environmental concerns, the USACE is responsible for the flood control, and must make regulatory discharges because of the high risk of loss of life and property associated with high lake stages and hurricane-generated waves and tides.

Alternatives are being sought, such as regional stormwater retention reservoirs, as described in the LECRWSP. These would have multiple benefits for water supply and protection of the estuaries.

B2b. Chronology and Current Status of the Regulatory Schedule

Early schedules are described by the USACE (1996). In 1965, the lake regulation schedule was modified to allow greater storage during the wet season. This was in response to the dry conditions of the early 1960's. After the summer and fall of 1965, a new schedule was developed to help deliver water to the Everglades National Park. In 1972, Zone C was discontinued and the lowest level on Zone B was raised up one-half of one foot in an attempt to increase water supply. Due to the extended dry period in the early 1970's, and increased water use requirements of the lake, the levee system surrounding the lake was improved so that the lake could safely be regulated between 15.5 ft. and 17.5 ft. NGVD, which went into operation in the summer of 1978.

In May 1992, an alternative lake regulation schedule, "Run 25," was put into effect for a 2-year period, (Figure 25) (Trimble and Marban 1989). The Run 25 schedule ranges from 15.60 to 16.75 ft. NGVD, with multiple operation zones that vary flood releases over a wide range before reaching maximum release rates. The purpose of the 15.60 to 16.75 foot regulation schedule was to reduce damaging flows to the St. Lucie Canal and Caloosahatchee River estuaries without sacrificing the flood control or water supply benefits derived from the lake. Run 25 was approved for implementation in December 1994, and is considered interim (as are all regulation schedules) because the Flood Control Act of 1968 authorized an additional four feet of water supply space in the lake. However, significant construction has not occurred to implement the higher schedule, nor is it being designed or included in the LECRWSP.

Figure 25. Lake Okeechobee regulation schedule: Run 25

At the request of the SFWMD, the local sponsor of the C&SF Project, and Governor Lawton Chiles, the Jacksonville District initiated a regulation schedule review study in 1995, the Lake Okeechobee Regulation Schedule Review (LORSS). The purpose of this study is to determine if a more ecologically beneficial schedule exists which simultaneously meets the C&SF Project objectives without any requirements in structural modifications to the Hoover Dike and its associated canals and structures. The study will be subject to a thorough environmental impact analysis and quantification of economic issues associated with implementation of a revised schedule. The LORSS will develop objective criteria for quantifying trade-offs between competing lake management objectives such as flood protection, water supply, water quality, protection of environmental resources, recreation and navigation. Once these criteria have been established, meaningful comparisons can be made between alternative lake regulation schedules. The recommended regulation schedule will be put into effect on an interim basis until such time as the C&SF Restudy is completed and implementation begun. The LORSS is scheduled to be completed in 1999.

C. WATER SUPPLY

Lake Okeechobee plays an important role in providing water to all of South Florida. During years of normal rainfall, the regulation schedule allows for an ample supply of water to be stored in Lake Okeechobee during wet periods for use during the dry season. However, south Florida's rapid growth produces ever increasing water demands on the system each year. The greatest use of water is agriculture, primarily in the EAA, but also along the St. Lucie Canal and Caloosahatchee River. Several small communities get water from C-43; Florida Power and Light withdraws water from the St. Lucie Canal, and the M and L-8 canals provide water to the City of West Palm Beach. Water from the lake is used directly by 5 small urban communities around the lake, and provides aquifer recharge for the coastal communities during prolonged droughts. Environmental water needs from Lake Okeechobee currently include the Water Conservation Areas and Everglades National Park. In addition, sufficient flows must be provided to the St. Lucie and Caloosahatchee estuaries in the dry season to prevent excessive salinity that is harmful to the biotic communities.

When there is not enough water available for present or anticipated needs, a water shortage and associated restrictions may be declared by the SFWMD Governing Board. The water shortage process is initiated when ground water and surface water levels fall to levels considered critical for the time of year and anticipated demands. There are different levels of drought that have corresponding levels of restrictions. Water shortage declarations range from a warning, which has voluntary moderate restrictions, through four phases of water shortage, to an emergency, which can restrict withdrawals up to the point of disallowing any further withdrawals.

The LECRWSP encompasses most of the water supply issues associated with Lake Okeechobee. These include a water budget for the lake, agricultural and urban demands, water shortages, minimum lake levels, supply side management, aquifer storage and recovery, and environmental needs of the water conservation areas, the estuaries, and the Everglades. In March 1993, the Draft Working Document and Draft Appendices were completed. A revised copy of the Draft Preview Document was printed revised and a second printed on March 31, 1995. The anticipated date for the final draft of the LECRWSP is September 1997.

C1. Water Budget Update

The 1993 SWIM Plan Update called for a study of the Lake Okeechobee water budget to determine the quantity of water in the lake at any given time. A draft water budget for the Lower East Coast Planning Area has been published in the LECRWSP (LECRWSP Draft Working Document, 1993), and will be updated in the final version of the plan. In addition, the SFWMD participated in a cooperative agreement with the USGS for a study of atmospheric deposition on Lake Okeechobee. Phase I of this study evaluated the sampling efficiency and variability of various atmospheric deposition sampling devices. This pilot study was conducted in the spring and summer of 1992. Utilizing information obtained in Phase I, a network of wet/dry deposition sampling sites within and around Lake Okeechobee was planned to be established in Phase II.

It was anticipated that information derived from this cooperative agreement would be used in the water budget calculations and be an important tool in reevaluating the regulation schedule for the lake, identifying water supply deficiencies and surpluses, and refining calculations of nutrient loading to the lake. However, the conclusions from the pilot study showed the difficulty of developing and utilizing such a network of wet/dry deposition sampling sites within and around the lake. This initial project was discontinued due to excessive sample contamination from birds and insects. A new effort is currently being developed by the SFWMD to obtain data on wet and dry deposition.

C2. Water Supply Demand Estimates

The LECRWSP will contain estimates of current water demands, and projected future demands through the year 2010 for all users within the Lake Okeechobee and Lower East Coast service areas (Figure 26). Estimates of non-environmental demands are based on population projections derived from local comprehensive plans, utility master plans, historical water use, and observed long-term trends in agricultural development. This information, along with estimates of water availability, is used to determine whether water supply is sufficient to meet projected demands of all major classes of users. The plan will include expected frequency of water shortages.

During the extreme dry months of April and May, the Caloosahatchee River may have almost no flow. When this condition prevails, navigation lockages through the W.P. Franklin Lock enables a saltwater wedge to move upstream. More lockages result in more saltwater moving upstream. Eventually, the chloride content of the water entering the municipal water intakes of Ft. Myers and Lee County exceed the drinking water standard of 250 ppm. When this happens,

Figure 26. Lake Okeechobee and Lower East Coast service areas.

SFWMD requests the USACE to flush out the saltwater with a short-term high rate of discharge from Lake Okeechobee. During a declared water shortage period the SFWMD requests the USACE to go to reduced hours of lockages.

C3. Determination of Environmental Water Supply Needs

As part of the water supply planning process during the LECRWSP, the SFWMD will determine environmental water supply goals in terms of stage, duration, timing and distribution of water for surface systems and the frequency with which these conditions must be met.

Initially, environmental needs were established when the scientific working group in support of the LECRWSP recommended that the Natural System Model (NSM) be used as the best available modeling tool for estimating those needs. The SFWMD has corrected some deficiencies in the NSM. Other hydrologic models are part of the estimate for environmental demands, such as South Florida Water Management Model (SFWMM). Various water delivery scenarios will be assessed to balance the ecological needs of the Everglades with competing water supply needs. The Everglades Landscape Model will also be used to evaluate water quality impacts to the Everglades.

Development of the LECRWSP will include testing of different Lake Okeechobee regulation schedules in an attempt to meet the demands of the users as well as environmental needs. The LECRWSP will include an analysis of the impact of implementing environmental needs on the health of Lake Okeechobee through the use of performance measures (see Chapter 4).

C4. Supply Side Management Plan

The Supply Side Management Plan is the procedure through which water supply allocations from Lake Okeechobee are determined during times of water shortage. In its briefest form, it states that the amount of water available for use during any period is a function of the anticipated rainfall, lake evaporation, and water demands for the balance of the dry season in relation to the amount of water currently in storage. Water availability from Lake Okeechobee is calculated on a weekly basis, along with a provision which allows users to borrow from their future supply to supplement existing shortfalls. The borrowing provision places the decision of risk with the user and can significantly affect the distribution of benefits among users because the amount of water borrowed is mathematically subtracted from future allocations. The Supply Side Management Plan is implemented if it is projected that the lake stage could fall below 11 ft. NGVD at the end of the dry season (May 31).

For Lake Okeechobee, the current procedure lies in the calculation of water demands. At the present time, this value is limited to estimation of irrigation demands in four agricultural basins: the North Shore, Caloosahatchee, St. Lucie, and Everglades Agricultural Areas. Lower east coast urban demands were omitted because they are not generally required during a normal rainfall year; however, they can be significant during drought periods. Another major omission from this calculation is environmental demand. As part of the LECRWSP, steps will be recommended to improve supply side management and water shortage management.

C5. Water Conservation Strategies

Prevention of wasteful, uneconomical, impractical or unreasonable uses of water resources is one of the principal directives outlined in the SFWMD's Water Supply Policy Document (1991). The SFWMD undertook a contract, completed in April 1992, which quantified domestic urban water use and conservation potential in the lower east coast of Florida. A set of measures for reducing long-term water demands through conservation measures such as water-conserving rate structures, retrofit of plumbing fixtures with low volume devices, xeriscape landscape ordinances, and other measures will be incorporated into the LECRWSP.

As a result of development of the Water Supply Policy Document and water supply plan recommendations, many conservation-oriented changes have been incorporated into the SFWMD's Basis of Review (BOR) for consumptive water use permit applications. Mandatory water conservation measures incorporated into the SFWMD's BOR for Water Use Permit Applications include water conservation plans for public water supply utilities, landscape and golf course irrigation projects. Water conservation elements for public water supply include irrigation ordinances, xeriscape criteria, ultra-low volume plumbing fixtures, conservation-based rate structures, leak detection programs and reclaimed water reuse feasibility studies. For agricultural projects, the BOR provides mandatory irrigation efficiency standards, and requires agricultural demand management measures including monitoring and reporting of water use.

C6. Water Supply Alternatives

As previously described, Lake Okeechobee's capacity as a water supply reservoir is limited. During past droughts, the lake was not able to meet existing demand, resulting in water shortages. When demand exceeds supply, there are two approaches to be taken: (1) reduce demands and/or (2) find an alternative source of supply. The feasibility of any water supply source is a function of its availability, and the consumers' willingness and ability to pay for it. The SFWMD is exploring alternative water supply sources in the LECRWSP and providing funding for alternative water supply projects with local governments and municipalities.

As part of its efforts to conserve freshwater resources in areas of high demand, the SFWMD will continue to analyze and support the development of alternative sources such as desalinized water or reclaimed wastewater. A reasonable amount of wastewater reuse will be required in designated areas of critical water supply concern. Desalination of brackish water from the upper portion of the Floridan Aquifer System also has potential as a source of water. The SFWMD is conducting a water supply reconnaissance study of this aquifer in southeastern Florida.

Among the augmentation strategies to be investigated through the SFWMD's planning initiatives are the development of water storage technologies, including above-ground reservoirs and ASR. ASR may be considered as the seasonal storage of acceptable water in an appropriate aquifer during times of surplus, for retrieval during times of deficit. The SFWMD completed the first phase of a demonstration project, exploring the use of ASR for both water supply and water quality remediation purposes, near Lake Okeechobee in December 1989. The SFWMD is also providing major funding to Broward County for an ASR project using treated water. The

LECRWSP will include extensive ASR studies. Development of additional surface water storage facilities, or more intensive use of existing ones, is also under consideration.

C7. L-8 Diversion

The Lake Okeechobee Technical Advisory Council (1988) recommendation for the L-8 Diversion Project has been rolled into the Everglades Protection Project as a result of the Everglades Forever Act. The conceptual design for the Everglades Protection Project included plans for the L-8 diversion works being operated to direct runoff from the north L-8 Basin. The water source is primarily from the Dupuis Reserve and the J.W. Corbett Wildlife Management Area, and will be directed to Lake Okeechobee via Structure S-76, Culvert 10A, and Pump Station S-309 (to be built). Analysis of phosphorus loading using the modified Vollenweider model (1978) indicates that the long-term loading target is slightly more achievable with this added source of clean water.